SURVEY OF OIL PRODUCTION IN WEST VIRGINIA BY WATERFLOODING, 1959

(In Three Parts)

1. Cow Run Sand, St. Marys Field, Pleasants County

By Charles E. Whieldon, Jr., and Robert M. Meddles

* * * * * * * * * * * information circular 7972

March 3, 1849

UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary

BUREAU OF MINES
Marling J. Ankeny, Director

This publication has been cataloged as follows:

Whieldon, Charles E

Survey of oil production in West Virginia by waterflooding, 1959. (In three parts) By Charles E. Whieldon, Jr., and Robert M. Meddles. [Washington] U.S. Dept. of the Interior, Bureau of Mines [1960]

v. illus., maps, tables. 26 cm. (U.S. Bureau of Mines. Informations circular 7972)

Bibliographical footnotes.

Contents.—1. Cow Run sand, St. Marys field, Pleasants County.

1. Oil field flooding - West Virginia. I. Meddles, Robert M., joint author. II. Title. (Series)

TN23.U71 no. 7972 622.06173

U.S. Dept. of the Int. Library

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C. - Price 20 cents

PREFACE

This report is the first of a series describing secondary recovery of oil by waterflooding in various counties of the State of West Virginia.

Recovery of oil by waterflooding was legalized by the State legislature in 1953. By January 1957 waterflooding had been initiated in eight counties. Separate Information Circulars will be prepared by the Federal Bureau of Mines for each of the three waterflooding projects studied.

In each report the introduction will summarize the results obtained by waterflooding; the discussion will present information on oil-production history and general geology of the county, specific lease-production history, waterflood development, lease geology, producing-sand characteristics, and source and treatment of water and will summarize operations on the waterflooding projects studied.

CONTENTS

Page

Preface.... iii
Introduction and summary.... 1
Acknowledgments.... 3
History of oil production in Pleasants County.... 3
General geology of Pleasants County.... 4
Discussion of waterflooding project.... 4
    Production history before waterflooding.... 4
    Waterflood development.... 8
    Producing-sand characteristics.... 9
    Source and treatment of water.... 12
    Summary of operations.... 13

ILLUSTRATIONS

Fig.

1. Map of West Virginia showing counties for which waterflooding reports have been published by the Bureau of Mines.... 2
2. Pleasants County (W. Va.) map showing general extent of St. Marys oilfield, location of waterfloods, and other historical and geological points of interest. 5
3. Map showing location and status of wells and leases, Dearborn Oil & Gas Corp., St. Marys field, Calcutta North lease, McKim and Washington districts, Pleasants County, W. Va., January 1959.... 6
4. Production history of Cow Run sand, Dearborn Oil & Gas Corp., Calcutta North lease, Pleasants County, W. Va., May 1959.... 7
5. Structure contour map showing top of Cow Run sand, Dearborn Oil & Gas Corp., Calcutta North lease, Pleasants County, W. Va.... 10
6. Isopachous map showing thickness of Cow Run sand, Dearborn Oil & Gas Corp., Calcutta North lease, Pleasants County, W. Va.... 11
7. Results of core analysis, F. K. Bills well ICR-18, Cow Run sand, Dearborn Oil & Gas Corp., Calcutta North lease, Pleasants County, W. Va.... 12

TABLE

1. Summary of operations.... 14

SURVEY OF OIL PRODUCTION IN WEST VIRGINIA BY WATERFLOODING, 1959
(In Three Parts)

I. Cow Run Sand, St. Marys Field, Pleasants County

by

Charles E. Whieldon, Jr.,[1] and Robert M. Meddles[2][3]

INTRODUCTION AND SUMMARY

The importance of recovering more oil from known petroleum reserves has placed increased emphasis on the application of secondary-recovery methods. It is hoped that these reports will stimulate interest in improved waterflooding techniques, thereby discouraging premature abandonment of oil leases.

A previously published report[4] described the highly successful results of waterflooding in the Weir sand in eastern Kentucky. A more recent report[5] evaluated the results of waterflooding in Roane County, W. Va. (See fig. 1.)

Two waterflooding projects have been operated in Pleasants County, W. Va. (fig. 2), one by the Dearborn Oil & Gas Corp. in the Cow Run sand near Calcutta, McKim and Washington districts, and the other by George C. Schoonmaker in the Maxton sand at Bens Run, Union district. This report report describes the waterflood operation near Calcutta, W. Va.

Drilling was begun in 1898 or 1899 on the six leases (325 acres) included in this survey and was very active in 1901 and 1902. However, oil-production data are available only from 1913 through 1959, during which time 224,000 barrels of oil was produced by the 800-foot-deep wells. Oil production was aided by gas repressuring until 1956, when gas injection was replaced by waterflooding.

---

[1] Engineering aid, petroleum, Bureau of Mines, Region V, Morgantown, W. Va.

[2] Former Bureau of Mines geologist, mineral fuels, Region V, Morgantown, W. Va.

[3] In preparing this report, the authors were assisted by W. M. Nabors, Joseph Pasini III, and W. E. Eckard, petroleum and natural gas engineers, Bureau of Mines, Region V, Morgantown, W. Va.

[4] Nabors, W. M., and Whieldon, C. E., Jr., Secondary-Recovery Operations on the L. C. Bailey Lease, Oil Springs Pool, Magoffin County, Ky.: Bureau of Mines Rept. of Investigations 5387, 1958, 17 pp.

[5] Nabors, W. M., Caspero, N. A., Pasini, Joseph, III, and Whieldon, C. E., Jr., Secondary Recovery of Oil By Waterflooding in the Big Injun Sand, Roane County, W. Va.: Bureau of Mines Rept. of Investigations 5601, 1960, 49 pp.

Original from THE OHIO STATE UNIVERSITY

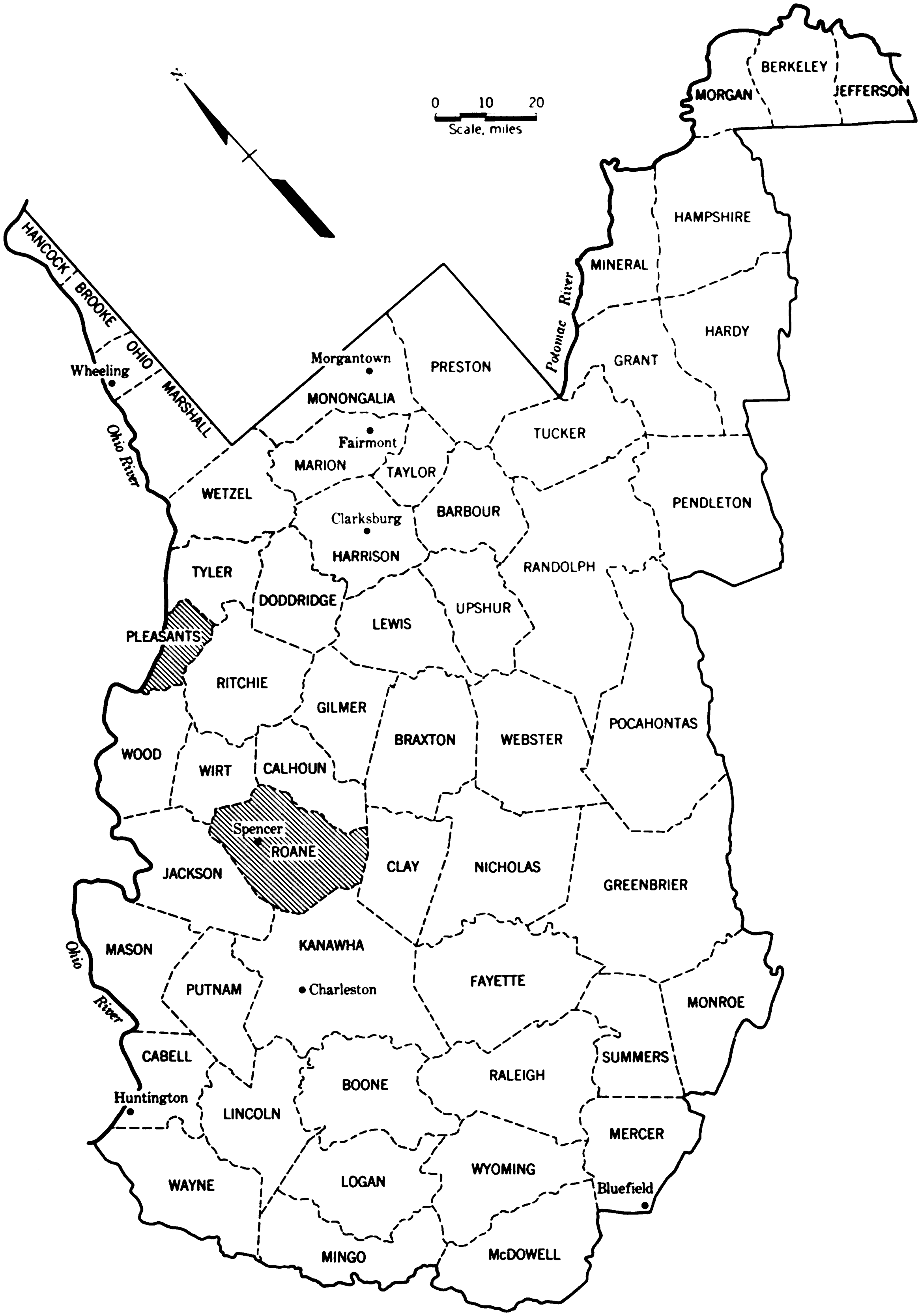

FIGURE 1. -Map of West Virginia Showing Counties for Which Waterflooding Reports Have Been Published by the Bureau of Mines.

Before the first waterflood was started in March 1956, daily oil production was about 6 barrels. After water was injected the producing wells were pumped at regular intervals, and the oil production declined to an insignificant amount. Water injection was discontinued in May 1959, after about 568,000 barrels had been injected.

ACKNOWLEDGMENTS

The writers gratefully acknowledge the cooperation of the officials and employees of the Dearborn Oil & Gas Corp., who made this report possible by furnishing information and statistical data on their operation.

Special thanks are extended to Leonard Hart, Dearborn Oil & Gas Corp., for his cooperation and assistance.

HISTORY OF OIL PRODUCTION IN PLEASANTS COUNTY

The first successful oil well in Pleasants County was drilled in 1864 on the east flank of the Burning Springs anticline in western Jefferson district (fig. 2). This well was completed to a depth of 400 to 500 feet in the Horseneck sand and was reported to have yielded 1,000 barrels of oil a day. Because the well was about 10 miles by road from the Ohio River and transportation costs to the river were $3.00 per barrel or more, an intensive search for oil was made nearer the river. Results were not significant. Many of these shallow wells were drilled using the "spring pole" method.

In 1889 the Little Gulch Oil Co. drilled several wells in Cooper Hollow, southwest of St. Marys, but activity in the St. Marys field was greatest from 1898 to 1904. The Arvilla field was discovered in 1905, and initial well production was as high as 200 barrels per day. Thereafter, oil development in the county spread north to Bens Run, along Middle Island Creek and French Creek, then across the county lines.6/

The first gas-cycling project in West Virginia began in the St. Marys field in 1903. A vacuum was pulled on the casing of the oil wells, and the produced gases were injected into recycling wells at 10 to 100 p.s.i.7/ Recovery of oil by air repressuring in West Virginia was started in 1916 in the Cow Run sand of the St. Marys field.8/ In 1956 waterflooding was begun near Calcutta, W. Va.

6/ Grimsley, G. P., Pleasants, Wood, and Ritchie Counties, W. Va.: Geol. Survey, County Reports, 1910, pp. 87-88.

7/ Headlee, A. J. W., Unpublished Rept. to Dinsmoor Oil Co. and Bailey Gas Co., 1952.

8/ Heck, E. T., Secondary Recovery of Oil in the United States. Chapter 10, Secondary Recovery in West Virginia: API, 1942, pp. 109-123.

GENERAL GEOLOGY OF PLEASANTS COUNTY

The surface geology consists of Permian and Pennsylvanian rocks. Most of the outcrops in the county are Permian rocks of the Dunkard series. A stratigraphic column showing important sands and coal seams is given below:

Period	Series	Formations
Permian	Dunkard	Marietta sandstone
		Washington coal
		Waynesburg coal
Pennsylvanian	Monongahela	Carrol sandstone
		Pittsburgh coal
	Conemauga	Minshall sandstone
		Murphy sandstone
		Moundsville sandstone
		Cow Run sandstone
		Little Dunkard sandstone
		Big Dunkard sandstone
	Allegheny	Burning Springs sandstone
		Horseneck sandstone
		Freeport coal

The Marietta sandstone forms the hills and cliffs of the north and central parts of the county. Some of these sandstone cliffs are 30 to 40 feet high. Washington coal lies directly below the sandstone and is the prevalent outcrop coal in the area.

Rocks of the Pennsylvanian period lie in the western part of the county on the crest and flanks of the Burning Springs anticline, which is the most prominent geological disturbance in the western section of the State. The axis of the structure is north-south and extends north into Ohio and south as far as Wirt County, W. Va. (fig. 1, p. 2). In the 1860's, this anticline was known as the Oil Break, and oil-well drilling was begun nearby. The flanks of the anticline dip steeply to the east and the west, exposing rocks of the Allegheny series.

The topography of the county is very rough and hilly and has an elevation difference of 300 feet, which makes travel and upkeep of farm roads difficult. The drainage of the area is dendritic, and the numerous streams in the area form valleys shaped like an amphitheater.

DISCUSSION OF WATER-FLOODING PROJECT

Production History Before Waterflooding

This property (fig. 3) was drilled first between 1898 and 1902 and then infrequently until 1953, when the last oil well was drilled (F. K. Bills 1A).

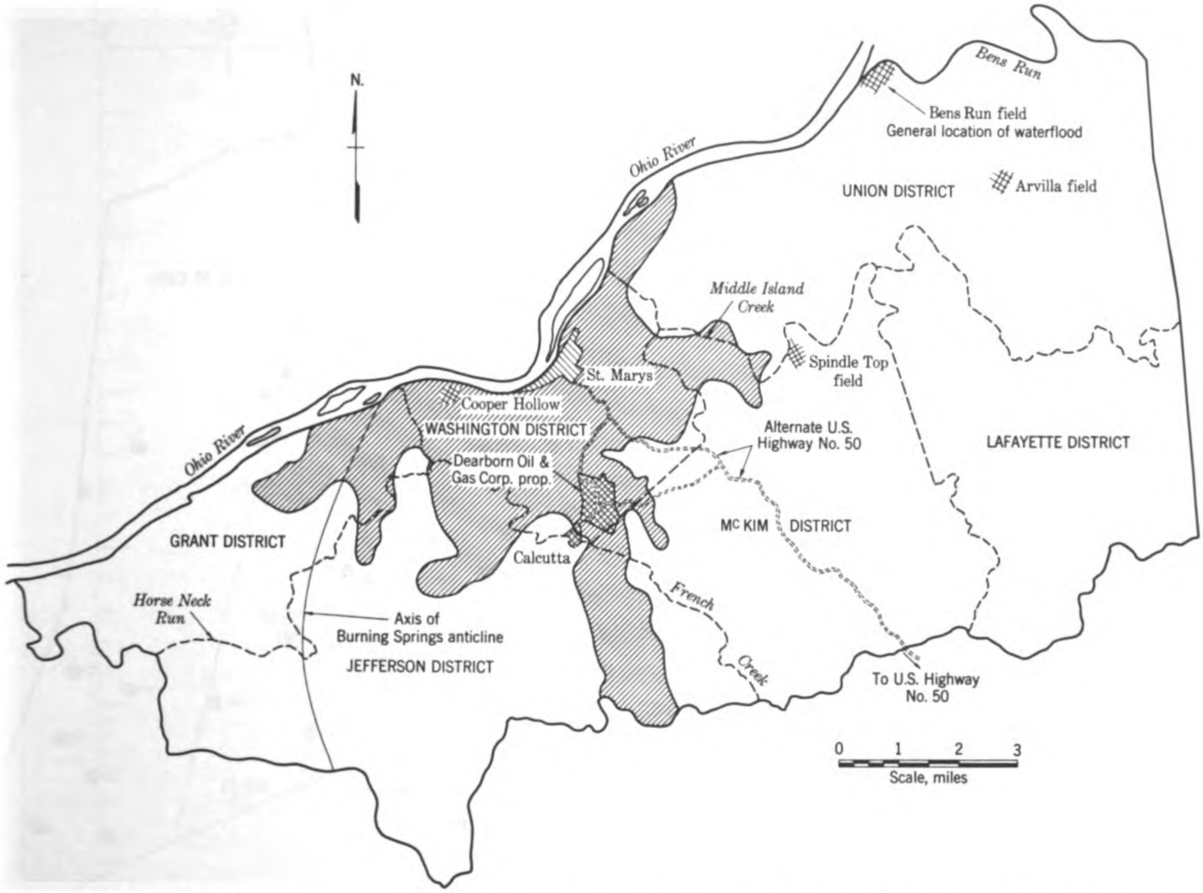

FIGURE 2. - Pleasants County (W. Va.) Map Showing General Extent of St. Marys Oilfield, Location of Waterfloods, and Other Historical and Geological Points of Interest.

Primary productive life of the early oil wells was very short--about 6 years. Vacuum and gas recycling were applied to some leases of the St. Marys field as early as 1903. It is not known whether these stimulative techniques were applied to the leases shown in figure 3 as early as 1903, although three gas-injection wells (L. Virgin 3 and 6 and G. B. Haddox 2) are included in the leases. During this early period the producing wells were pumped on a high vacuum, and the produced gas was continuously recycled into the sand at pressures up to 100 p.s.i.

Oil-production records from these leases (fig. 4) were not available before 1913. Between 1913 and 1955, the total volume of oil produced annually declined from an average of 9,000 to 2,000 barrels. Oil production from the E. M. Cole lease increased from 1,252 barrels in 1916 to 4,555 in 1917, making the volume of oil produced from the six leases (10,249 barrels) the largest in any year, but no records are available to account for the increase. The leases were operated by air- or gas-injection methods until the fall of 1955, when the operators began drilling new water-injection wells.

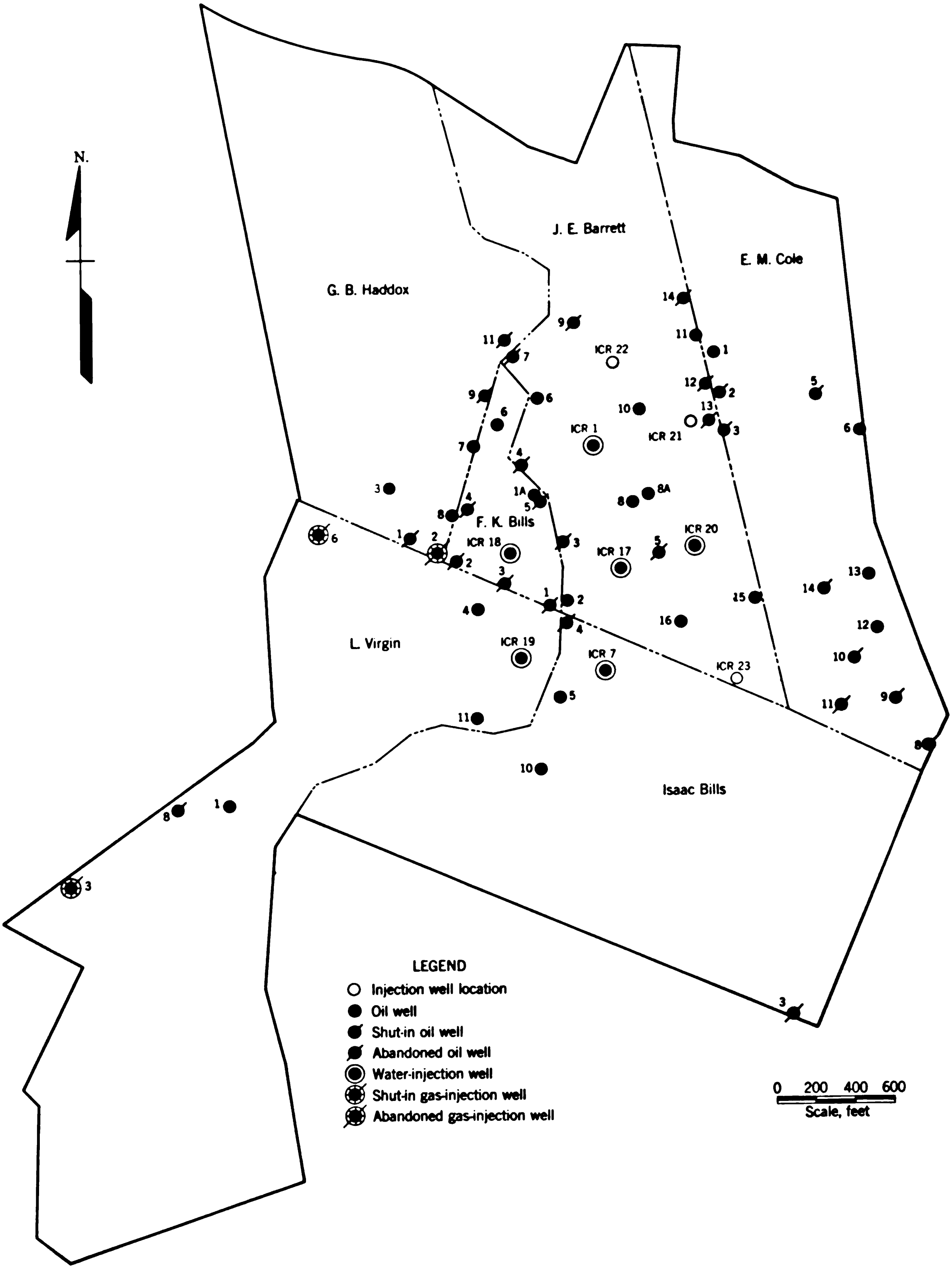

FIGURE 3. - Map Showing Location and Status of Wells and Leases, Dearborn Oil & Gas Corp., St. Marys field, Calcutta North Lease, McKim and Washington Districts, Pleasants County, W. Va., January 1959.

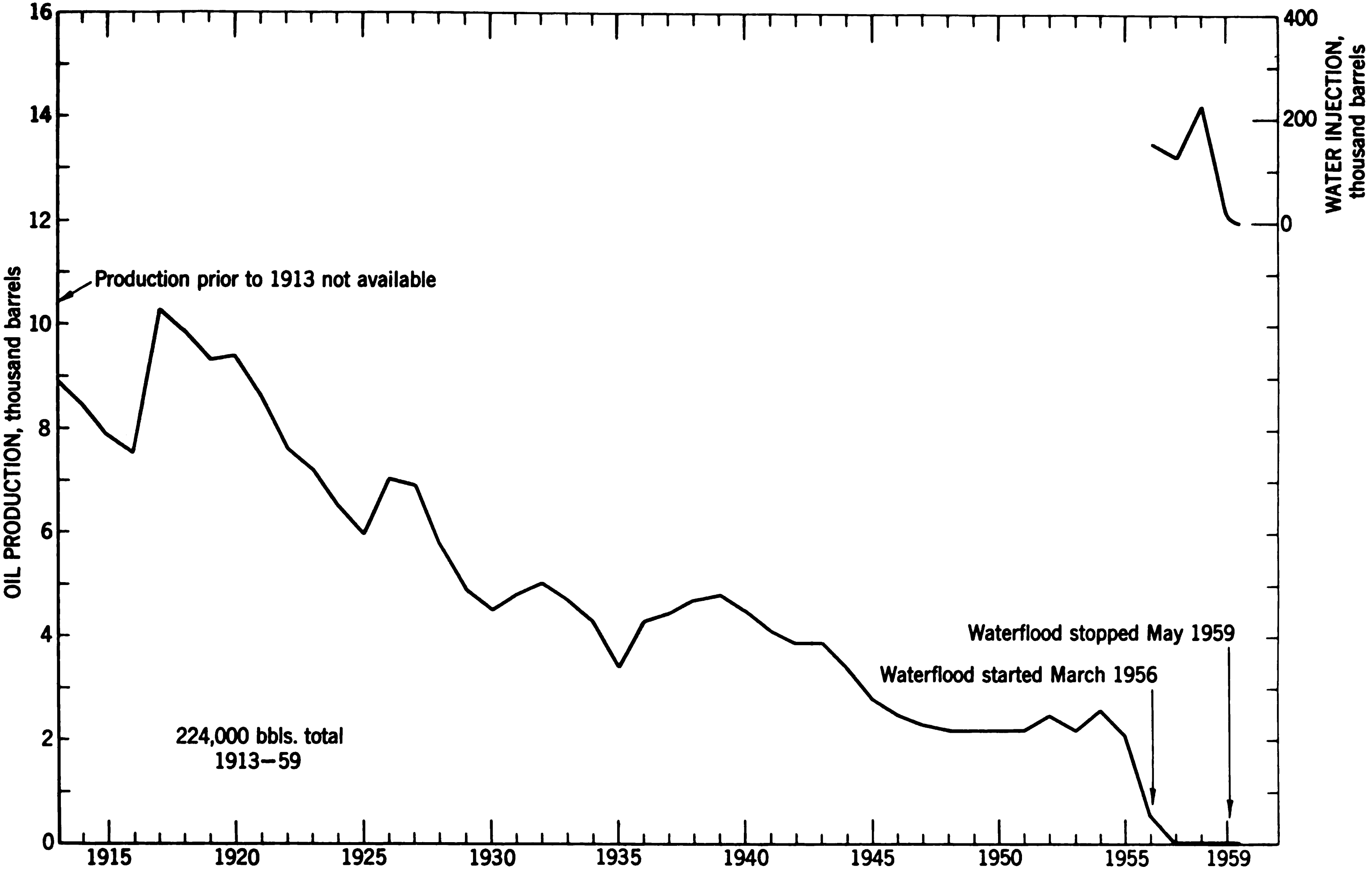

FIGURE 4. - Production History of Cow Run Sand, Dearborn Oil & Gas Corp., Calcutta North Lease, Pleasants County, W. Va., May 1959.

Data on properties of the Cow Run sandstone crude oil, taken from analyses made in 1952,[9] follow:

Viscosity in centistokes	4.32 @ 60° F. 2.73 @ 100° F. 2.10 @ 130° F. 1.23 @ 210° F.
Viscosity index	162
Cloud point	50° F.
Specific gravity	0.8000 @ 60° F.
Refractive index	1.4412 @ 77° F.
Surface tension	24.4 dynes per cm.
Interfacial tension	26 dynes per cm.
Sulfur	0.089 percent
Color	Light green

Waterflood Development

Between October 1955 and January 1956, injection wells ICR 17, 18, 19, and 20 (fig. 3) were drilled and completed with rotary tools in 3 to 4 days. Then they were equipped with 50 to 100 feet of 8-inch casing to exclude surface water and cavings. A 5-1/2-inch string of injection casing was set 2 feet into the producing sand and cemented to the surface. The rotary rig was removed and a portable spudder used to ream and remove sand cutting. During these operations considerable caving occurred in the producing sand. Upon completion of cleanout operations the four wells were tamped-shot with enough solidified nitrogylcerin to fill the well bore opposite the producing formation. The amount of explosive used per well ranged from 155 to 325 quarts. Two old producing wells (ICR 1 and 7) were converted for water injection. These wells were cleaned out and completed with 5-1/2- to 6-inch production casing and cemented to the surface. Water was injected through the production casing in these wells as it was in the newly drilled injection wells. The six injection wells formed two irregular five-spot patterns, with well ICR 17 common to both patterns.

The 22 producing wells (fig. 3) were equipped with approximately 180 feet of 8-1/4-inch casing and 750 feet of 6-1/4-inch casing. The smaller casing string was set just above the Cow Run sand. A 10- to 15-foot pocket was drilled below the bottom of the sand to catch cavings. All producing wells were shot with 40 to 100 quarts of nitroglycerin. These wells were equipped with pumping jacks and produced through 2-inch tubing with a bottom-hole pump on sucker rods.

During development of the waterflood, 10 old wells were plugged and cemented to the surface to keep water in shallower formations from entering the producing sand.

---

[9] Work cited in footnote 7, p. 3.

Well spacing between an injection well and a firstline, offset producing well ranged from 250 to 500 feet.

Producing-Sand Characteristics

The Cow Run is a shoestring sand found in old streams and valleys. It is light gray, clean, coarse, and rather permeable. The sand is sometimes referred to as a low-rank graywacke. The cementing material is a carbonate and ranges from 5 to 28 percent of the total sample volume. In this sand, the larger the grain size the more completely it is cemented; thus, the porosity and permeability are affected. The areas with the least cement contain the smaller sand grains; therefore, a decrease in grain size indicates an increase in porosity and permeability. Fluid flows will be most active in areas with the smaller sand particles and the least cementation.[10]

The structure map (fig. 5) shows the top of the Cow Run sand, and the isopachous map (fig. 6) shows the Cow Run sand interval. Both maps were constructed using drillers' logs.

Four commercial core analyses of the Cow Run sand from wells ICR 17, 18, 19, and 20 were available for this study. These wells were cored with rotary diamond-coring equipment using waterbase mud as the drilling fluid. Figure 7 shows the graphic results of tests made on the cored formation of well ICR 18.

Of the four wells cored, three (ICR 17, 18, and 20) had low permeabilities (an arithmetical average of 6.9 millidarcys). The remaining well (ICR 19) had an average permeability of 29.7 millidarcys. The porosity in the cored formations ranged from 3.6 to 18.2 percent, with an overall average of 12.1 percent. Residual oil saturations ranged from 0 to 19.2 percent of the pore space and had an arithmetical average of 8.9 percent. Water saturations ranged from 57.5 to 96.3 percent and averaged 75.1 percent. This high-water saturation undoubtedly was due largely to excessive invasion of the drilling fluid. Capillary-pressure measurements on core material from well ICR 17 were used to estimate the connate-water saturation in well ICR 19, which was 47.2 percent of the pore space. An estimated value of 50 percent connate water was used on the remaining three wells.

The core analyses show the following calculated oil recoveries:

Recoverable oil	ICR 17	ICR 18	ICR 19	ICR 20
By natural or gas expansion.............................bbl. per acre-foot	93	96	101	96
Increase due to waterflood.............................bbl. per acre-foot	254	267	325	275
Total after complete waterflood.................bbl. per acre-foot	347	363	426	371

---

[10] Griffiths, John C., Petrography and Porosity of the Cow Run Sand, St. Marys, West Virginia: Unpublished Rept. to Dearborn Oil & Gas Corp., 1956.

Original from THE OHIO STATE UNIVERSITY

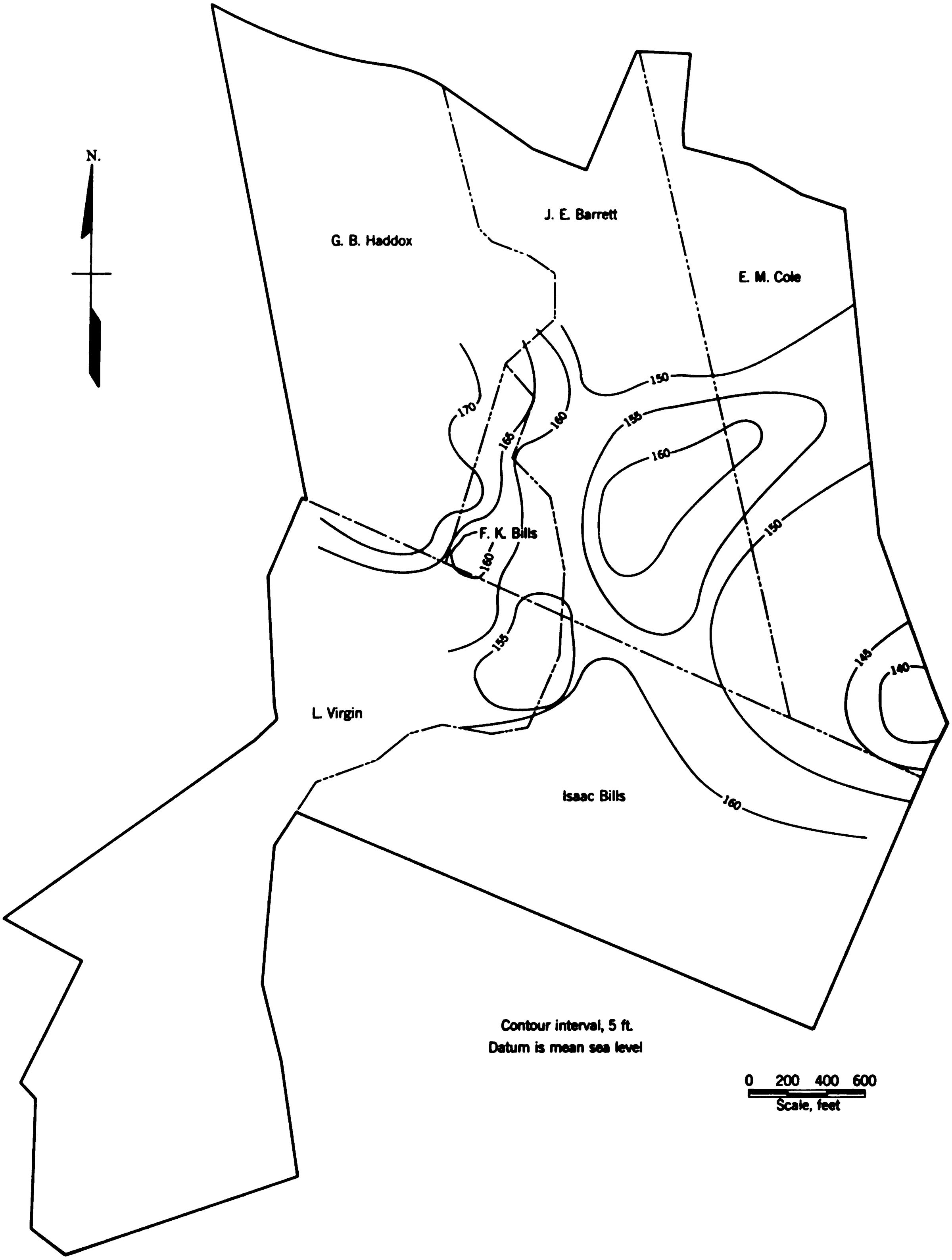

FIGURE 5. - Structure Contour Map Showing Top of Cow Run Sand, Dearborn Oil & Gas Corp., Calcutta North Lease, Pleasants County, W. Va.

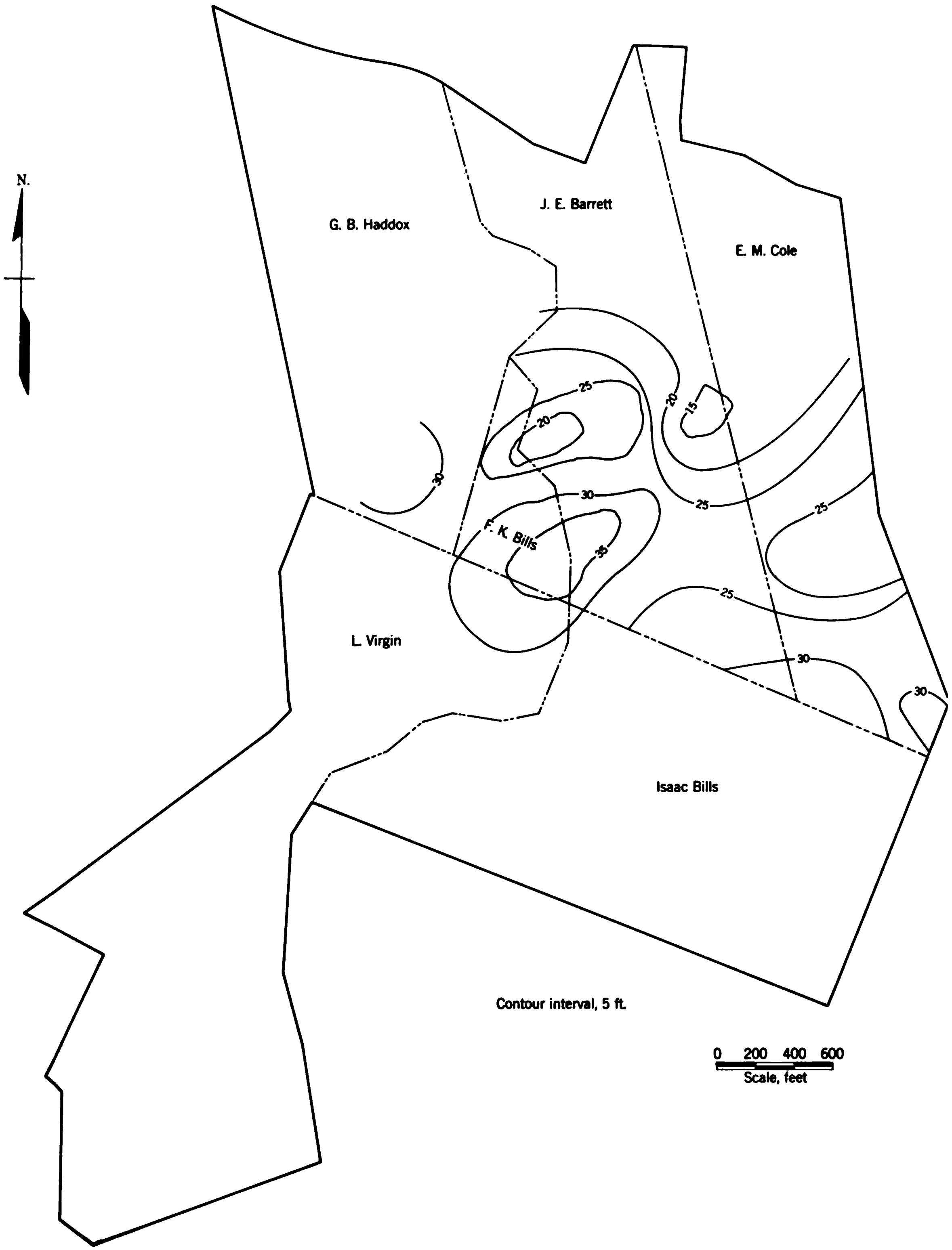

FIGURE 6. - Isopachous Map Showing Thickness of Cow Run Sand, Dearborn Oil & Gas Corp., Calcutta North Lease, Pleasants County, W. Va.

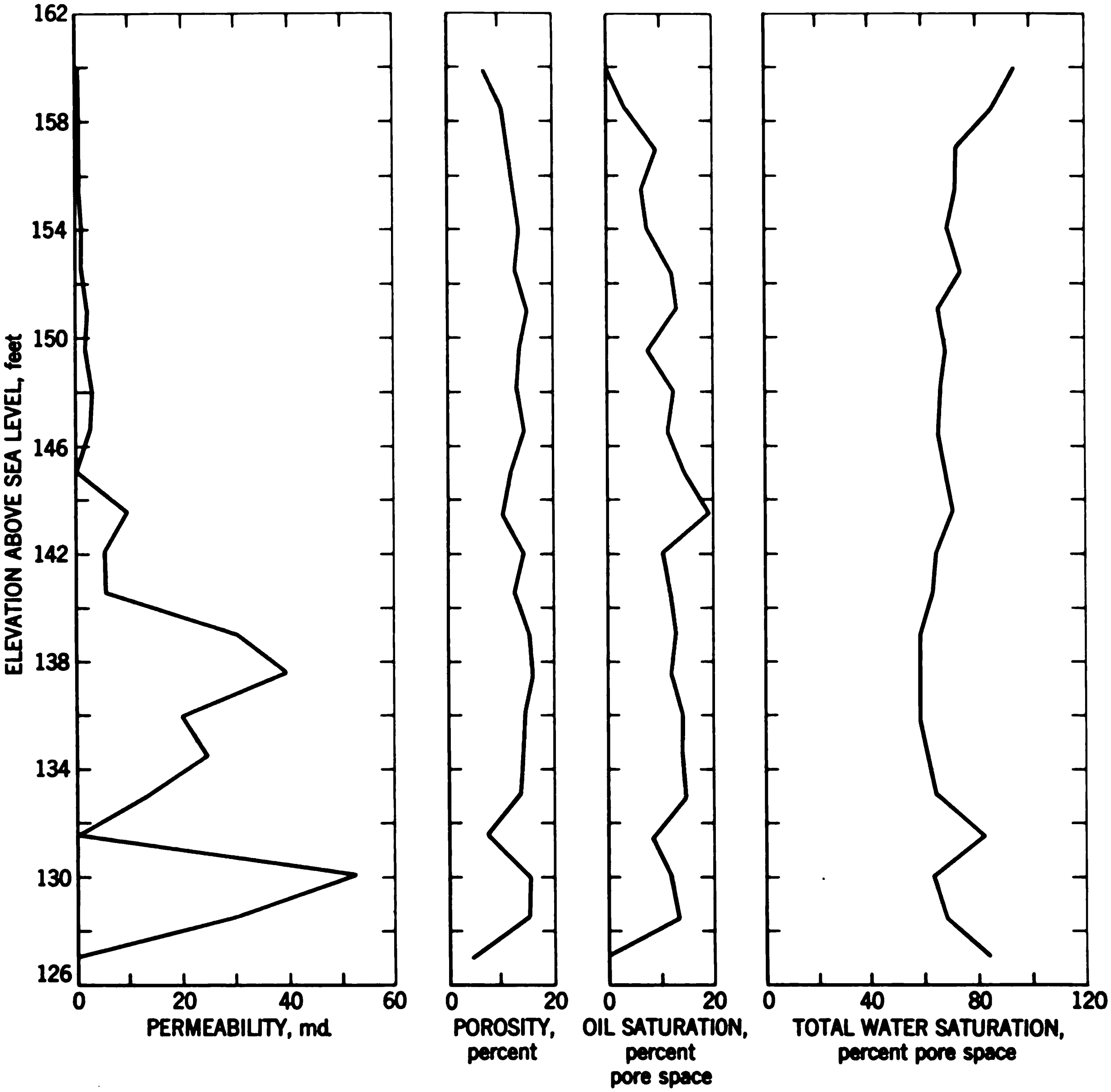

FIGURE 7. - Results of Core Analysis, F. K. Bills Well ICR-18, Cow Run Sand, Dearborn Oil & Gas Corp., Calcutta North Lease, Pleasants County, W. Va.

Source and Treatment of Water

Three wells approximately 100 feet deep, not shown in figure 3, supplied fresh water for injection. Water entering the settling tank was chemically treated with caustic soda to stabilize the pH value, sodium hypochlorite to control organic growth, and sodium hexametaphosphate to inhibit corrosion. After it left the settling tank, the treated water passed through a pressure-type anthracite filter into a clear-water storage tank. Two horizontal triplex pumps, each with a rated capacity of 1,000 barrels per day at 900 p.s.i., supplied water to the injection wells.

Summary of Operations

Table 1 summarizes annual oil production from 1913 through 1956, volumes of water injected each month from 1956 through May 1959, and pertinent information on the waterflood area.

TABLE 1. - Summary of operations

Location: Pleasants County, W. Va.
Sand flooded: Cow Run
Depth to top of sand: 800 feet
Sand thickness: 25 feet
Area under flood: 15 acres
Well pattern: Irregular 5-spot
Total acreage involved: 325 acres

Total active oil wells: 22
Total inactive gas-injection wells: 3
Total water-injection wells: 6
Type of water and system: Fresh - open
First water injection: March 1956
Gravity of oil: 43.6° API

Record of oil production

Year	Barrels	Year	Barrels	Year	Barrels
1913[1]	8,922	1928	5,755	1943	3,916
1914	8,448	1929	4,899	1944	3,453
1915	7,865	1930	4,553	1945	2,841
1916	7,493	1931	4,770	1946	2,498
1917	10,249	1932	4,996	1947	2,325
1918	9,857	1933	4,670	1948	2,221
1919	9,328	1934	4,280	1949	2,192
1920	9.419	1935	3,451	1950	2,155
1921	8,667	1936	4,335	1951	2,198
1922	7,590	1937	4,455	1952	2,516
1923	7,195	1938	4,746	1953	2,180
1924	6,512	1939	4,873	1954	2,572
1925	5,974	1940	4,528	1955	2,140
1926	7,054	1941	4,093	[2]1956	[3]528
1927	6,896	1942	3,950		

Record of water injection

Month	Water injected, barrels			
	1956	1957	1958	1959
January		11,193	11,427	17,356
February		10,280	12,652	14,631
March	323	10,782	13,509	12,593
April	5,406	10,044	18,296	17,235
May	18,141	10,152	21,305	[4]9,261
June	25,282	9,652	18,535	
July	22,437	10,132	22,320	
August	18,564	9,868	20,230	
September	16,253	9,461	18,483	
October	17,681	10,066	20,973	
November	15,528	10,498	19,655	
December	13,150	10,587	19,136	
Total	152,765	122,715	221,421	71,076

[1] Prior production not available.
[2] Waterflooding began.
[3] First 3 months production.
[4] Water injection discontinued May 16, 1959.

U.S. GOVERNMENT PRINTING OFFICE: 1960 O - 553088